The Current State of the Clam, *Galatea paradoxa,* Fishery at the Lower Volta River, Ghana

Adjei-Boateng*, D., Agbo, N.W., Agbeko, N.A., Obirikorang, K.A., Amisah, S

Department of Fisheries and Watershed Management, Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana

*Corresponding Author

ABSTRACT

The clam, *Galatea paradoxa* has for decades been an important source of protein to the riparian communities of the lower Volta River and provides employment to about 2000 people, especially women. The fishing grounds have dwindled from 100 km from the pre-dam era to a narrow stretch of 10 km as a result of the development of sand bars at the estuary. This study was conducted to ascertain the socio-economic importance of the clam fishery to the people of the lower Volta, Ghana. The research found out that there were 251 fishing canoes and 503 fishers engaged in the clam fishery. The average daily catch per fishing canoe was 130 kg of clams, with an annual harvest of 7700 tonnes worth 4,620,408 Ghana Cedis. Commercial extinction of *G. paradoxa* is imminent in the lower Volta as a result of habitat alteration and overfishing. There is the need to put in place a sustainable harvesting measure that will target medium to large size clams against the current situation where the catch is dominated by smaller clams. It is recommended that a minimum landing size of 50 mm should be imposed. This should be done in consultation with the chiefs and traditional authorities in the communities which have managed the fishery to date. The marketing of clams below the 50 mm shell length limit should be abolished and enforced by the traditional authorities. Secondly, the farming of smaller clams, which is a traditional activity in the estuary, should be encouraged so that fishers who harvest undersize clams can seed them onto their culture plots.

INTRODUCTION

Galatea paradoxa (Born 1778) is a bivalve mollusc belonging to Order, Veneroidea, Superfamily, Tellinoidea and the family Donacidae (1) and is usually restricted to the lower reaches of a few rivers in West Africa including the Volta in Ghana (2, 3, 4). The species has two trigonal thick shells with two valves held together by the adductor muscle. *Galatea paradoxa* is the basis of an artisanal fishery at the Volta estuary, Ghana which constitutes an important and affordable protein source to the riparian human communities of the Lower Volta. It has for centuries supported the livelihood of 2000 people (5). Additionally, the shells of the clam has a number of important uses notably as source of calcium in animal feed, especially poultry feed and in the manufacture of lime and paints. The shells are also used as an alternative to stone chippings in concrete and as pavement material such as terrazzo floors and to overcome muddy conditions in village compounds in the southern parts of the Volta Region, Ghana (6).

The construction of the Akosombo and Kpong hydroelectric dams on the Volta River in 1964 and 1981 respectively, altered the flood patterns in the lower Volta resulting in the formation of

sandbars at the mouth of the Volta River. This prevented the intrusion of seawater upstream during high tides (7). The alterations in the flow regime led to physicochemical changes in the water and consequently, a gradual shift in the habitat of *G. paradoxa* from the upper and mid-section of the lower Volta River towards the estuary with a substantial decline in abundance of the clam (Figure 1).The ensuing habitat modification coupled with over-exploitation has led to a significant reduction in the population of this commercially important species. The distribution of *G. paradoxa* is currently restricted to a narrow stretch of 10 km between Agave-Afedume (15 km) and Ada-Foah (5km) from the estuary (5). The current range of *G. paradoxa* is about a tenth of the pre-dam period when the clam bed stretched between Sogakope and Akuse (between 20 and 95 km from the estuary) (2) (Figure 1). Landings from the clam fishery have also drastically dwindled from 8000 tonnes per annum (2) prior to the construction of the Akosombo dam, to 1700 tonnes per annum (8).

Commercial extinction of the clam is imminent in Ghana with dire socio-economic consequences for villagers, especially women whose livelihoods depend on the fishery. Presently, there is some practice of culturing clams in the lower Volta which involves seeding juvenile clams to individual or family-owned plots for on-growing during the fishing season (March – December). This practice ensures the continuous availability of clams for domestic consumption and sale during the closed-season (December – March) each year (9, 10).

Dredging activities carried out by the Volta River Authority (VRA) in 1990 and 2009 at the Volta estuary allowed the intrusion of seawater into the river creating suitable conditions for the resurgence of the clam fishery at some portions of the lower Volta River, this cannot however, be compared to the pre-dam period. Anecdotal information indicates that, the higher increases in the annual clam harvest could be attributed mainly to the adoption of more sophisticated harvesting methods and the harvesting of juveniles clams which hitherto were not landed. This research was therefore conducted to ascertain the fishing effort, catch, exploitation methods and the socio-economic benefits of the clam fishery to the communities of the lower Volta in Ghana.

METHODOLOGY

Study Area

The study was conducted in December 2009, at Ada Foah in the Dangbe East District of the Greater Accra Region and Agave Afedome and Sogakope in the South Tongu District in the Volta Region of Ghana. Ada Foah located on Latitude 05°49' 18.6" N and longitude 000°38.46' 1"E and Agave-Afedome, latitude 05°53 28.2" N and longitude 000° 38' 24.7"E. The two sites are the most active clam fishing grounds on the Volta River (Figure 1).

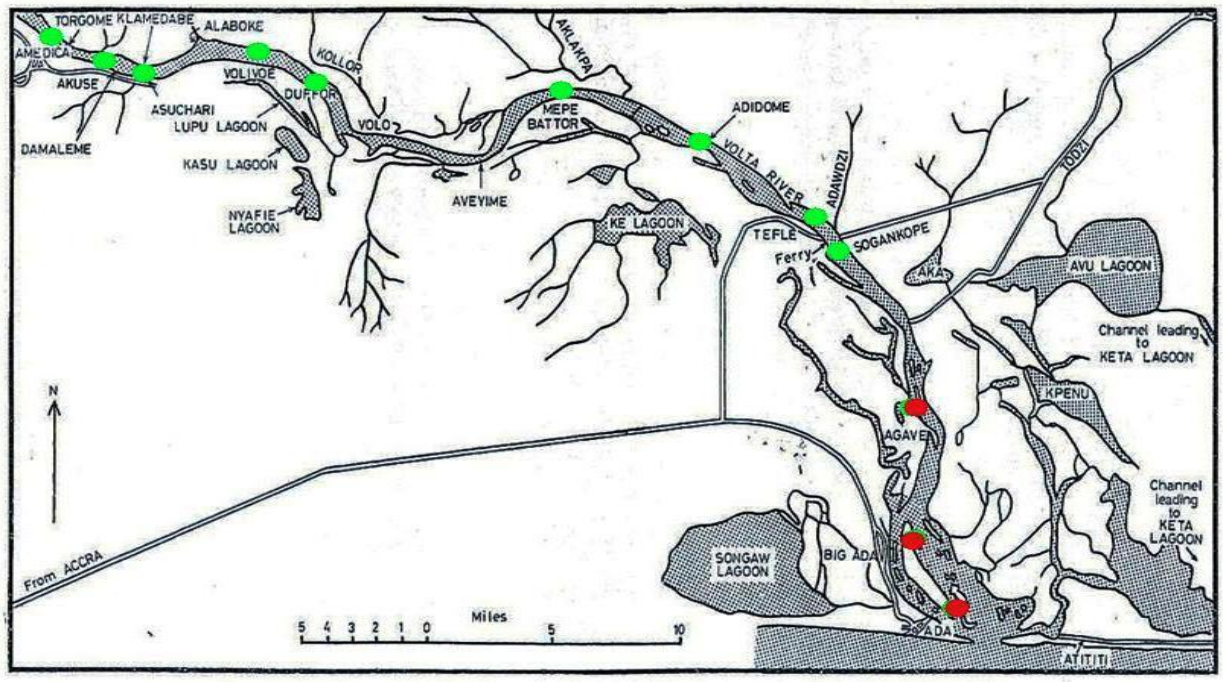

Figure 1. The range of *Galatea paradoxa* in the lower Volta River: Green dots represent the previous range of the clam prior to the construction of the Akosombo Dam; Red dots represent the current clam fishing areas (Original map courtesy (2).

Estimation of fishing effort.

A complete count was used to estimate the number of canoes and clam fishers at Ada Foah and Agave Afedume. Aided by a motorise canoe, the total number of canoes and the fishing crew per canoe was counted on six fishing days over the study period from Agave-Afedome to Ada Foah between 11am to 3pm daily. The results of all the counts were summed up and the mean per day calculated.

Estimation of Total Output

In order to estimate the total catch of the fishery, the most active clam landing beaches at Ada Foah and Agave-Afedome were each visited during the survey between 3 and 6 pm daily; a period within which the daily catch was landed. In all, 75 clam fishing canoes were sampled to give a near-accurate estimate of the catch per day of a single fishing canoe. The daily clam harvest from each canoe was weighed using a spring balance. The estimated daily clam harvest per canoe was multiplied by the total number of canoes engaged in the fishery during the survey period to obtain the total catch per day. The estimated total daily catch of the fishery was further multiplied by the number of fishing days taking into consideration the closed- season and taboo days to estimate the total annual output.

Identification of exploitation methods

Clam fishing crews were visited by means of a motorised canoe to enable a close observation of the harvesting methods and gears used. A further description of what happens underwater was provided by the clam fishers.

Identification of Socio–Economic Benefits

Questionnaires were designed to solicit detailed information from the clam fishers, processors and retailers at the main centres of clam fishing and processing namely; Ada Foah, Agave Afedome and Sogakope. In all 90 respondents made up 30 fishers, processors and retailers each were interviewed. The questionnaires included social data (age, sex, other means of employment, activities during the close season, etc.), fishing activity (period of the year engaged in the fishery, methods of clam harvesting, fishing zone, etc) and details of the most recent fishing trips (catch size and composition, number of fishers involved in the fishery). The questionnaire also collected costs and revenue from the fishers, processors and retailers in order to estimate the cost and returns associated with the fishery.

RESULTS

Canoes and Fishers

Table 1 presents the number of canoes/wooden boats used by artisanal clam fishers in the Volta estuary. There were on average 251 canoes and 503 artisanal Hookah clam fishers, with each canoe operated by at least two fishers. The number of canoe clam fishers excludes the traditional hand collectors and other occasional collectors whose catch is made up of a few animals that are either sold or used for home consumption.

Table 1. Number of canoes and artisanal clam fishers in the Volta Estuary, Ghana

Mean No. of canoes	Range	Mean No. of fishers	Range	Mean no. of fishers/canoe	Range
251	213-305	503	416 - 598	3	2 - 4

Clam Harvesting

Clam harvesting commences at the beginning of March each year after the end of the traditionally imposed closed season. Two main methods are employed; traditional hand collection and Hookah fishing. The traditional hand collection method was previously the only method of clam harvesting in the Lower Volta until the introduction of the Hookah fishing method in the 1990s. The traditional hand collection method is limited to the shallow zones of the river and is mostly practiced by women who wade through the water, locate the clams with their feet and pick them with their hands into a container (Figure 2). Thirty women engaged in hand collection of clams were counted during the survey.

Figure 2. Women harvesting clams in the shallow areas of the Volta Estuary.

Hookah fishing is practiced solely by men who dive at the deeper zones of the river to collect the clams. The method involves the supply of air by compressors through a long hose to the fishers while submerged (Figure 3), allowing the fisher to remain underwater for 30 - 60 minutes. A diving mask is worn and the fingers protected with cellotape as the fingers are used to rummage the sandy sediments for clams that burrow below the surface with only their siphons protruding through the sand into the water. The fisher dives to the river bed with a net into which the harvested clams are placed.

Figure 3. A Hookah fisher preparing for a dive

There have been instances of compressor failures but these rarely result in fatalities as clam divers operate in waters that are less than 10 m and usually one diver remains aboard the canoe to alert the others of compressor stoppages. Clam fishing is restricted to a 10 km stretch of the river between Ada Foah and Agave Afedome, although there is limited harvesting of clams upstream. Figure 4 presents some of the accessories used and activities during Hookah fishing.

Fig 4A. A motorized air compressor

Fig 4B. The air supply hose

Fig 4C. Hauling the net aboard after fishing

Fig 4D. Unsorted clam in a canoe

Fig 4E. Sorting the daily harvest into size classes

Fig 4F. A 10-litre bucket used as a measure of daily harvest and sale

Estimation of Output and Revenue

It was estimated that an average of 130 kg of clams (total weight) are landed daily per canoe (Table 2). The harvest largely consisted of small clams (shell length < 40 mm) which account for 43%, followed by 38% of medium sized-clams (41-60 mm) and 19% of large-sized clams (> 60 mm). The fishery is therefore dominated (81%) by clams that are < 60 mm long. The closed-season for clam fishery is for a period of 77 days from 24th December to 11th March. Aside this period there is no fishing on Tuesdays and Sundays are optional fishing days. A clam fisher therefore works 4-6 hours a day in a 5-6 day week adding up to 236 days in a year. The estimated catch for the 251 fishing canoes is 7700 mt (Table 2). For the small and medium sized clams, a 10 litre bucketful (Figure 4F) is sold between 4.00- 8.00 Cedis. A 3-man boat crew on average harvest 130 kg of clams which is sold for 78 Cedis (1 USD = 1.45 GH Cedis). Through a chain of suppliers, clams are marketed to processors in the major towns of south-eastern Ghana.

Table 2. Catch statistics for artisanal clam fishing in the Volta Estuary, Ghana

Mean Catch (kg) per canoe (kg)	**Range**	**Total Catch per day (kg)**	**No. of fishing days**	**Catch per year (kg)**	**Value of catch per year(GH¢)**
130	90-170	32,630	236	7,700,680	4620408

1 USD = 1.45 GH Cedis

Socio-economic Benefits of the Fishery

Table 3 shows the categories of people employed directly in the clam fishery or ancillary activities and their average daily and yearly gross incomes.

Table 3 Gross incomes of categories of people employed in clam fishing or ancillary activities

Category	**Revenue Day^{-1} (GH¢)**	**Per Year^{-1} (GH¢)**
Clam fisher	26*	3,086,408
Clam processor	65	474,500
Clam Retailers	12.5	525,500
Clam shell mills		534,000
Total		**4,620,408**

*Gross income of GH¢78/canoe/day was estimated, divided by the 3-member crew 78/3= GH¢26

Processing of Clam Meat

The most valuable part of the clam is the meat which is a delicacy and is processed and sold at major roadside stop-overs. The processing method is simple and involves initial boiling to open the shells after which the meat is taken out and washed to remove sand particles. It is then skewered and fried (Figure 5). The main locations for the sale of fried clams are along the major highways in south-eastern parts of Ghana at Atimpoku on the Accra-Ho Highway and at Kasseh and Sogakope on the Accra-Aflao Highway. Clam processors obtain their supply from fishers at two landing beaches at Agave-Afedome and Big Ada.

Figure 5 .Frying of skewered clams and batch of fried clams ready for sale

Utilisation of the Clam Shell

The shell accounts for about 70% of the total weight of the clam. Out of the estimated 7700 tonnes of clams harvested annually almost 5400 tonnes of shells accrue after the meat has been extracted. Locally the shells are used as a pavement material on village roads and compounds to overcome muddy conditions. Additionally, they are used in decorating buildings e.g. stairs (Figure 6A-B). Mills have been established to process the shells into grit and powder for sale to other industries. Shells are purchased in truckloads mainly from Big Ada and Sogakope which are the major clam meat processing towns. The price for a truckload of shells is GH¢ 100.00 and approximately 120 bags of milled shells can be obtained from a truckload. The shells are milled at different grades of fineness depending on its intended purpose, bagged in 50 kg sacks and sold at GH¢ 4.00 per sack (Figure 6F). In a month, approximately 1600 bags of milled shells are produced, giving a gross monthly income of GH¢ 6400.00.

The milled shells have several uses and serve both the local and international markets. The animal feed industry, especially poultry feed producers' utilise the milled shells or grit as a source of calcium in animal feed. The milled shells are also used in the building industry in the construction of terrazzo floors. Powdered shells are used in the production of whitewash, which is cheaper than imported brands. The survey revealed that the cement industry also utilises the milled shells as a component in the production of cement

Fig 6A. Clam shell-paved lane in a village at Big Ada

Fig 6B. Staircase decorated with shells

Fig 6C. Heaps of shells at Big Ada

Fig 6D. A clam shell mill at Sogakope

Fig 6E. A Shell Mill

Fig 6F. Bagged milled shells ready for sale

Management and Conservation of the Fishery

The most important management measure of the fishery is the closed-season which commences from 24th December to 11th March each year. The institution of the closed season was in response to the small size of clam meat during this period. Aside from the closed-season, Tuesdays are non-fishing days for all fishermen. The closed season is strictly adhered to and is maintained by traditional norms and rites. The reasons for the timing of the non-fishing day are based mainly on indigenous knowledge and traditional beliefs. It also allows the fishers to market their clams as Tuesday is a market day. The clam fishery is open access as no permit is required before entry. Nevertheless, the chiefs of the Ada and Agave traditional areas have responsibility to ensure compliance with the traditional laws and regulations. Apart from the traditionally imposed restrictions there are no restrictions on the quantity or the size of clam harvested.

One management strategy which has prevented the extinction of the species in the Volta River is the farming or fattening of juvenile or smaller clams. In order to supply the market with clams during the closed-season, clam fishers usually seed shallow areas of the river with small size clams for periods ranging from 6 – 8 months. This enables the clams to double their size before being harvested for sale during the closed-season. Small sized clams are seeded to shallow zones of the river demarcated by sticks. The seeding of plots with clams and their harvesting is usually undertaken by women because of the shallowness of the areas. Clams do not move more than a metre away from their seeded points and, therefore, remain within the plots of their owners.

DISCUSSION

Galatea paradoxa Fishery

Artisanal clam fishing plays an important role in the socioeconomic life of inhabitants of the Volta Estuary. The clam beds stretched for 70 km from Akuse (100km) to Tefle (30km) from the mouth of the river prior to the construction of the dams (Figure 1). The number of people directly and indirectly engaged in the fishery and the methods used have been the subject of previous studies. Between 1000 and 2000 women were engaged in the fishery (2), (5) reported 111 women fishers at Battor, a fishing village on the Volta River. The current study estimated 30 women and 503 men with 251 canoes operating between Agave Afedome and Ada Foah, the main clam fishing area at the Volta Estuary.

In 1964, soon after the closure of the Akosombo Dam, the annual harvest was estimated at 8000 tonnes (2). Clam harvests ranged between 4000 and 7000 tonnes per annum (11). The yield, however, dropped to 1400 tonnes in 1987 (3) after the formation of a sand bar at the mouth of the river. In 2000, an annual yield of 1700 tonnes was estimated (8). The present study estimated an annual yield of 7700 mt within a restricted area of about 10 km^2. The increase in yield was owing to an increase in fishing effort and the introduction of air compressors which enables clam fishers to dive in deeper areas of the river and to stay underwater for longer periods searching for clams. Another reason for the higher annual yield is the landing of smaller clams. Previously, smaller clams (< 50 mm) were not landed and fishing was restricted to shallow areas with hand collection as the only method of fishing. Diving was only possible for a few experienced divers. The methods of clam fishing have evolved over the years (2) reported that hand collection and diving in the shallow zones were the only method used and the clam fishery was wholly conducted by women (1, 2).

Currently, two methods are used; hand collection mainly by women and diving by men. The bulk (90%) of the catch comes from the diving method in the deeper zones of the river where the density of clams is high. The fishery is very important to the socioeconomic well-being of the Ada and Agave communities not only as source of food and employment but also as source of raw material (shells) for small-scale industries even beyond the estuary. Annually, it generates a gross income in excess of GH¢ 4,620,408 (3,192,835 USD).

Commercial extinction of *G. paradoxa* is imminent in the estuary as a result of habitat alteration and overfishing and requires immediate regulation to conserve this vital resource. There is the need to put in place a sustainable harvesting measure that will target medium to large size clams against the current situation where the catch is dominated by smaller clams. The closed season, although important as it allows the clams to recover after the spawning period, does not prevent the landing of smaller clams. A study on the production and biomass ratio (P: B) showed that productivity was highest in the 3-4 year old clam after which it declined. Gamete output averaged 10% in the 6-year old clam at a mean shell length of 64.5 mm. Therefore, it would have been appropriate to fix the minimum landing size at 65 mm. However, the catch data from the fishery shows that only 19% of harvested clams are > 60 mm shell length. Fixing an unrealistic target for a fishery that is open access and community-managed would lead to illegal fishing and defeat the purpose for implementing the size restriction (Unpublished data).

In order to prevent the extinction of the clam and to ensure that the communities continue to benefit from the fishery, it is recommended that a minimum landing size of 50 mm be imposed. The 50 mm size limitation corresponds to the mean size of a 4 year old clam. The imposition of the restriction should be done in consultation with the chiefs and traditional authorities in the two communities which have managed the fishery to date. The marketing of clams below the minimum landing size should be abolished and enforced by the traditional authorities. Secondly, the farming of smaller clams which is a traditional activity at the estuary should be encouraged so that fishers who harvest undersize clams can seed them onto their culture plots.

CONCLUSION

The Volta clam fishery provides a source of livelihood for the inhabitants of the communities around the Estuary. The ancillary socio-economic activities of the fishery mainly include harvesting and processing of clams for consumption and the utilisation of milled clam shells by the construction and poultry feed industries. The total annual output of clam fishery has improved markedly since the introduction of the Hookah method. The current output however, indicates an unsustainable trend which might lead to the collapse of the fishery in the near future, taking into consideration the reduced range of the clam in the River.

ACKNOWLEDGEMENTS

The authors are grateful to Department of Fisheries and Watershed Management, Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana for the logistical support for this research.

REFERENCES

1. Purchon, R.D. (1963). A note on the biology of *E. radiata* Lam (Bivalvia, Donacidae). *Proceedings of the Malacological Society of London* 35: 251-271.
2. Lawson R.M. (1963) The economic organization of *Egeria* fishing industry on the Volta River. *Proceedings of Malacological Society of London*. 35: 273-287
3. Attipoe, F.Y.K. and Amoah C. (1989) Ecological and economic problems associated with the Volta Dam - the case of the *Egeria* and *Macrobrachium* fisheries of the lower Volta. Paper presented at the Ghana National Seminar on Inland Fisheries and Aquaculture, 22-25 August 1989. 20 pp (Mirneo).
4. King, R.P. and Udoidoing, O.M. (1991) Perspectives in the development and conservation of freshwater fisheries resources of the Cross River, Nigeria. *Transitional Nigerian Society of Biological Conservation,* 2, 7-16.
5. Amador, M.K. (1997) A review of the Volta clam, *Egeria radiata* fishery in the Lower Volta. BSc. Thesis submitted to the Dept. of Fisheries and Watershed Mgt, KNUST, Kumasi, Ghana.
6. Obirikorang K, Adjei Boateng AD, Amisah S (2009) Consumption of the clam, *Galatea paradoxa* (Born, 1778) in Ghana: human health implications with reference to heavy metals.Water Qual Exposure Health 1:191–201
7. United Nations Environment Programme (UNEP) Project Development Facility (2002) Volta River Basin Preliminary Transboundary Diagnostic Analysis-Final Report
8. Kumah, L.A. (2000). The status of the Volta Clam *Egeria radiata* (Lam) Fishery, and the Potential for its Culture-Based Fishery. An MPhil. Thesis submitted to the Department of Fisheries and Watershed Management, Kumasi, Ghana.
9. Prein, M. and Ofori, J.K (1996) Past initiatives for promoting aquaculture in Ghana, p. 1-3. *In* M. Prein, J.K. Ofori and C. Lightfoot (eds.) Research for the future development of aquacuiture in Ghana. ICLARM Conf. Proc. 42, 94 p.
10. Brown, J. H. (2006) Shellfish culture in West Africa; economic and sustainable opportunities for artisanal fishing communities. Background paper for FAO/DFID SFLP Policy brief series, FAO
11. Pople, W. (1966) Comparison of the Egeria fishery of the Sanaga River, Federal Republic of Cameroon, with that in the Volta River, Ghana. Tech. Rep. 12, 5 p. Volta Basin Research Project, University of Ghana.